PATENT
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UNITED STATES PATENT APPLICATION

of

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for

COMBUSTION PROCESS WITH A PREFERENTIAL INJECTION OF A CHEMICAL FOR POLLUTANT REDUCTION

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COMBUSTION PROCESS WITH A PREFERENTIAL INJECTION OF A CHEMICAL FOR POLLUTANT REDUCTION

Related Applications

[0001] This patent application claims the benefit of, under Title 35, United States Code, Section 119(e), U.S. Provisional Patent Application No. 60/413,726, filed September 26, 2002.

Field of the Invention

[0002] This invention generally relates to a technique to reduce pollution components from a combustion process and more specifically to a technique to reduce such pollution components with the injection of chemicals.

Background of the Invention

[0003] Chemicals have been injected into burners and furnaces for the purpose of reducing emissions or controlling the chemical reactions that might be harmful to heat transfer surfaces. One such technique is described in U.S. Patent 6,048,510 to Zauderer wherein ammonia or urea is injected into the gaseous combustion products in a manner that widely disperses droplets into optimum and identified reaction zones. The droplet sizes are selected so that their vaporization occurs exclusively in an optimum NOx urea/ammonia reaction temperature zone. It is recognized in this patent that high temperatures and an oxidizing atmosphere

in most combustion reactions either destroy or reduce the reactivity of the chemicals being injected. Ammonia oxidizes when oxygen is present and temperatures are above 3100 degrees Fahrenheit.

[0004] The Zauderer patent also provides an extensive description of various prior art techniques for the removal of NOx components from combustion gases using injected chemicals for both SNCR (selective non-catalytic reaction) as well as SCR (selective catalytic reaction) processes.

[0005] One problem with the injection of chemicals into combustion processes is that the chemicals have to be injected outside of the flame envelope and as a result tend to be poorly mixed with the byproducts of combustion which then defeats their intended purposes of reducing pollutants such as NOx gases.

Summary of the Invention

[0006] With a technique in accordance with the invention the combustion process is controlled so as to enable one to inject pollutant-reducing reagents or chemicals into a nearby turbulent combustion zone without a destruction of the chemical by high temperatures. This enables the chemical to be widely dispersed by the nearby zone before reaching the more distal zone where typically more favorable conditions prevail and thus enable the chemical to react with undesirable components of combustion and reduce pollutants such as NOx.

[0007] As described herein for one embodiment in accordance with the invention, a burner having typical high peak temperatures in a first turbulent zone near the entry of fuel into the combustion region is altered so as to have a peak temperature that is below the temperature at which a chemical useful to remove nitrogen oxides would dissociate or have its activity destroyed. While this peak temperature is reduced in the first zone, the chemical is injected in the first zone. This zone's turbulence causes the chemical to be dispersed without being destroyed during its transit time to reach a second distal combustion zone where nitrogen oxides prevail in conditions favorable for their removal by the chemical.

[0008] The reduction of the peak temperature in the first or nearby zone can be done in a variety of ways. For example, a substoichiometric fuel rich zone can be created in the first zone whereby the peak temperature is sufficiently reduced. Alternatively, the first zone can be subjected to a cooling with water droplets or by mixing in portions of byproducts of combustion such as flue gas or by limiting the amount of oxygen from secondary air.

[0009] During the time such substoichiometric conditions have been created in the high temperature zone near the entry point for the fuel, the chemical useful to control pollutants produced during the combustion process can be delivered to the

region where it can be most effective while being widely and advantageously dispersed throughout the turbulent first zone.

[0010] A broad range of pollutants can in such manner be either removed from the combustion process or be rendered harmless by virtue of being chemically altered and their emissions reduced. Thus the chemical being introduced can be selected to control NOx or SOx emissions or sulfur or sodium or heavy metal emissions such as mercury and/or vanadium. These chemicals can be delivered by way of a powder or by way of being dissolved in water droplets. The sizes of the water droplets are selected so as to enable the chemically laden droplet to survive transit through the first turbulent zone so as to reach the second or treatment distal zone intact to treat the polluting components.

[0011] It is, therefore, an object of the invention to provide a technique to remove pollutants from a combustion process. It is a further object of the invention to insert a chemical to remove pollutants in combustion zones having conditions most favorable for such removal by controlling zones less favorable to the vitality of the chemical that needs to pass through the controlled zone. It is a further object of the invention to enhance the effectiveness of a chemical injected into a combustion process by limiting the peak temperature of a zone through which the chemical needs to pass so as to maintain the integrity of the chemical.

[0012] The invention and its particular features and advantages will become more apparent from the following detailed description considered with reference to the accompanying drawings.

Brief Description of the Drawings

[0013] **Figure 1** is a cross-sectional view of a schematically illustrated staged burner with particular combustion zones of interest;

[0014] **Figure 2** is a cross-sectional view of an unstaged burner with particular combustion zones of interest;

[0015] **Figure 3** is a cross-sectional view of the distribution profile of one type of pollutant, NOx, within a burner;

[0016] **Figure 4** is a cross-sectional view of the injection profile of a chemical introduced in a burner to reduce NOx in the combustion process;

[0017] **Figure 5** is a cross-sectional view of a typical temperature profile established to enable the injection of chemical in accordance with the invention; and

[0018] **Figure 6** is a cross-sectional view of a typical oxygen profile established to enable the injection of chemical in accordance with the invention.

Detailed Description of an Embodiment of the Invention

[0019] With reference to Figure 1 a staged burner 10 is shown operating within a furnace and is shown in a schematic manner. A stream of a chemical, as suggested with dashed lines 14, is introduced into the combustion zone 16 to reduce a combustion pollutant such as NOx. The chemical can be selected from a variety of chemicals. For purposes of illustration and not limitation, urea or ammonia, for example, could be used, along with any of numerous other chemicals, for NOx reduction. The chemical can be encased within liquid droplets to survive the transit of a hot nearby zone 1 located in front of the burner 10.

[0020] The staged burner 10 typically has various combustion zones characterized by a turbulent flame zone 1 anchored in front of burner 10. Zone 1 is highly turbulent and can be characterized as having generally a temperature and stoichiometric profile suitable for NOx reduction with a rapid reagent injection (RRI). A zone 2 is characterized by high temperatures, which tend to be too hot for a lean selective non-catalytic reaction chemistry (SNCR). A distal zone 3, located after the nearby zone 1, also tends to less favorable for the reagent used to reduce NOx in the combustion zone. Distal zone 4, typically has a more suitable temperature and stoichiometric ratio for RRI chemistry.

[0021] However, zone 4 is located quite aft in the combustion zone 16 and preferably is reached with the injection of reagents after these have been widely distributed by the more turbulent but hotter zones 1 and 2. Accordingly, the invention involves reducing the peak temperatures of the zones 1 and 2. Such temperature limitation is preferably achieved by operating these zones under sub-stoichiometric conditions. Alternatively, the peak temperatures of these zones can be limited by way of an injection of an appropriate cooling medium such as water.

[0022] Sub-stoichiometric conditions in zones 1 and/or 2 can be obtained by creating zones with either very high fuel to air ratios or very low fuel to air ratios so that the peak temperature of chemicals traveling through the zones does not exceed the chemicals' deterioration limits. The sub-stoichiometric conditions can be obtained by way of slowing the introduction or by reducing the amount of secondary air, or by way of introducing over-fired air or by assuring a fuel rich region with a staging of the air within the burner. Such sub-stoichiometric zones can be achieved by injecting a gas or by injecting a liquid. Once such lower peak temperature condition has been attained the natural turbulence of the combustion process within the zones can be relied upon to thoroughly mix the chemicals with the products of combustion before the chemicals reach the destination zones such as zone 4.

[0023] The lowering of the peak temperatures in a zone 1 is not sufficient to protect the injected chemicals from deterioration since temperatures are still quite high. Accordingly, it is preferred that injected reagent chemicals are encapsulated within liquid or aqueous droplets that are so sized as to survive transit through the hot regions while evaporating by the time that the chemicals reach the distal zones to be treated by the reagent. Alternatively the reagent chemicals can be encapsulated within a refractory material or a solid material with the encapsulations being ablated within the hot proximal transit zones. Other encapsulation materials can be oils or the reagent can be merely retained in a liquid suspension.

[0024] In another case the reagent can be introduced within a stream of gas that is selected to protect the reagent during its transit through intermediate hot zones. The protective gas can envelop the reagent and when imparted with sufficient velocity can traverse the hot zone, though with less mixing by the turbulent intermediate zone. In such case the protective gas can produce a sub-stoichiometric channel through a zone in which the peak temperature exceeds the deterioration temperature of the reagent within the channel without destroying the reagent before it reaches the desired zone.

[0025] As shown in Figure 1, the reagent chemicals are preferably introduced from a central place in burner 10. However, this location may not always be available and so side located injectors 20 can be used to introduce the chemicals.

[0026] Figure 2 illustrates combustion zones for an unstaged burner 20. This burner produces combustion zones 1', 2' 3' and 4' having similar and corresponding characteristics as for the zones described in connection with Figure 1.

[0027] Figure 3 shows the profile 24 of NOx produced within the combustion zone 16 of the staged burner in Figure 1 and in Figure 4 a profile 28 is shown for the reagent chemical introduced to eliminate pollutants such as NOx. Figure 5 illustrates a temperature profile 32 for a staged burner of Figure 1 and Figure 6 an oxygen profile 36 for this burner.

[0028] Although the invention has been described with reference to a particular arrangement of parts, features and the like, these are not intended to exhaust all possible arrangements or features, and indeed many other modifications and variations will be ascertainable to those of skill in the art.